



NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA #2000-0226-2890
Foeste Masonry
Cape Giarardeau, Missouri

July 2001

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health



PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Daniel Yereb and Paul Hewett, of the Respiratory Disease Hazard Evaluation and Technical Assistance Program, Field Studies Branch (FSB), Division of Respiratory Disease Studies (DRDS). Other DRDS staff were involved. Analytical support was provided by Data Chem Laboratories. Desktop publishing was performed by Terry Rooney.

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Health Hazard Evaluation Report 2000-0226

Foeste Masonry Cape Girardeau, Missouri July 2001

Daniel Yereb
Paul Hewett

SUMMARY

Foeste masonry recently received an OSHA citation for overexposure of workers to crystalline silica during the dry cutting of brick. Foeste subsequently purchased several brick/block cutoff saws equipped with water dust suppression. Until Foeste could show that exposures were adequately controlled, Foeste was required by OSHA to enroll the operators in a respiratory protection program (fit testing and use of half mask, cartridge respirators). On April 3, 2000, Foeste Masonry requested a Health Hazard Evaluation (HHE) to assess the effectiveness of wet dust suppression during the cutting of brick and block. On May 8, 2000, NIOSH investigators met with Foeste representatives to discuss sampling procedures for collecting airborne dust samples. Environmental measurements of airborne particulate were obtained on May 9 - 10, 2000.

NIOSH investigators determined that dry cutting can lead to intense exposures to silica dust. Such exposures are likely to be very hazardous to workers operating the saws and working in their vicinity. NIOSH recommends that wet cutting be used when ever possible. The sampling undertaken in this study indicates that wet cutting, undertaken using the manufacturer's guidelines, generally leads to exposures to silica dust below the OSHA PEL. It is recommended that saw operators continue to wear at least a NIOSH-approved, disposable respirator, especially when wet cutting for two hours or more. If dry cutting brick or block is necessitated by the building design a Powered Air Purifying Respirator (PAPR) should be worn and the cutting time should be limited. Routine evaluation of dust exposures is desirable to ensure that the workers are adequately protected , especially for brick or block of high silica content.

Keywords: Silica, Quartz, Silicosis

TABLE OF CONTENTS

Preface	ii
Acknowledgments and Availability of Report	ii
Summary	iii
Introduction	1
Background	1
Methods	1
Results	2
Discussion	3
Conclusions	4
Recommendations	4
References	5
Tables and Figures	6
Appendix	15

INTRODUCTION

On March 13, 2000, the safety manager of Foeste Masonry contacted NIOSH by telephone to discuss a dust control problem. Foeste Masonry had received an OSHA citation for overexposure of workers to crystalline silica during the dry cutting of brick. Foeste had purchased several brick/block cutoff saws equipped with water dust suppression, but was required by OSHA to enroll the operators in a respiratory protection program (fit testing and use of half mask, cartridge respirators) until Foeste could show that exposures were adequately controlled. On April 3, 2000, NIOSH received a formal request from Foeste masonry to conduct a Health Hazard Evaluation (HHE) to assess the effectiveness of wet dust suppression during the cutting of brick and block.

On May 8, 2000, NIOSH investigators met with Foeste representatives and discussed the scope of the investigation, reviewed existing environmental and administrative controls, conducted a walk-through of the facilities, and examined the equipment. Airborne respirable dust samples using wet and dry cutting methods were collected on May 9 - 10, 2000.

This report presents the results from the industrial hygiene survey conducted May 9 - 10, 2000. The effectiveness of using wet dust suppression while cutting brick and block is addressed. In addition, recommendations for preventing exposure to crystalline silica are presented.

BACKGROUND

Foeste Masonry undertakes masonry work for commercial construction sites. The site of concern in this report is owned by the county of Cape Girardeau, Missouri. The county had contracted with Foeste Masonry to build a 21,000 square feet addition to the Cape Girardeau Justice Center. The interior walls and building envelope were constructed of block while the building facade was covered with brick. In addition to the masonry work, electricians, pipe-fitters, plumbers, and HVAC contractors were on site. As a common practice in the construction industry, plumbers, electricians, HVAC contractors, and others perform "rough-in work" prior to the masonry work. As a result, there

is considerable cutting of block and brick in order to cover up the rough-in work. Some construction contracts either forbid wet cutting (wet brick, block or tile may not set up properly with some adhesives) or require the brick/block to be dried several hours prior to use. Brick or block drying prior to use is not always practical given the nature of masonry work.

Foeste Masonry was cited under the OSHA Permissible Exposure Limit (PEL) for dusts containing crystalline silica. This PEL (see the appendix) is calculated using a formula that reflects the combination of two components: (a) level of respirable dust (i.e., dust small enough to penetrate to the air exchange regions of the lung where clearance and detoxification are difficult), and (b) the percentage of crystalline silica in the dust.

METHODS

On May 9-10, 2000, NIOSH investigators collected both personal breathing zone and area airborne dust samples during dry cutting (Figure 1) and wet cutting (Figure 2) of brick and block at the Foeste Masonry construction site in Cape Girardeau, Missouri.

Thirty-three area and personal airborne dust samples were collected. Sampling was done using two to four industrial hygiene sampling arrays that were placed around the cutting stations, at approximately chest height and 4 to 5 feet from the saw. Each sampling array contained two cyclones, one impactor, and two direct reading instruments (for respirable dust). Three video cameras were positioned around the cutting stations to videotape the cutting cycle. Sample times ranged from 10 to 76 minutes.

Respirable Dust Containing Crystalline Silica

Area and personal samples of respirable dust were collected and analyzed using NIOSH Method 7500: Silica, Crystalline by X-ray Diffraction (XRD).¹ Each dust sample was collected with a battery-powered sampling pump calibrated at 1.7 liters per minute (L/min), 10 mm nylon cyclone followed by a 37-mm diameter polyvinyl chloride (PVC) filter. The nylon cyclone removed the larger, non-respirable particles from the air stream prior to passing through

the filter. The filters were weighed prior to the survey. After sampling, each filter was again weighed so that the mass and concentration of collected dust could be determined. If the weight gain of the filter exceeded 0.03 mg (the limit of detection for silica in NIOSH method 7500), the filter was analyzed for crystalline silica (quartz).

Particle Size Distributions

The particle size distribution for dust was measured using Andersen Personal Cascade Impactors, Model 298. Prior to sampling, 34-mm diameter Mylar® substrates were silicone-coated and pre-weighed by NIOSH. Each sample was collected using a battery-powered sampling pump calibrated at 2.0 liters per minute (L/min). Thirty-four-mm diameter polyvinyl chloride (PVC) filters were used as a backup to the Mylar® substrate to prevent leaching of the silicone to the stages of the impactor. Substrates were post-weighed to measure the amount of particulate collected. The impactor data were collected as part of ongoing NIOSH research in aerosol particulate and will be reported when that research is complete.

Real-time Dust Measurements and Video Recordings

Respirable dust real-time measurements were made using the Personal DataRAM (MIE) with data-logging capabilities. The DataRAM was calibrated to 1-second sampling intervals. Simultaneous video recordings of each cutting cycle were collected and merged with real-time dust measurements. Video-overlays were produced to access peak exposures during cutting. Internal clocks in the DataRAM and video cameras were synchronized to the second. Video tape recordings with real-time overlay of the airborne dust concentration were prepared for two one minute segments illustrating dry and wet sawing operations. This was done to access peak exposures during the sawing process and to provide information on other variables such as wind direction that can affect the concentration of airborne dust in the work area.

RESULTS

The results obtained in this study illustrate that exposures to airborne dust can occur during dry and

wet cutting of block and brick. They provide a powerful demonstration of the potential risks of undertaking dry cutting, and a clear indication of the merits of wet cutting. Note, however, that the data are snap shots in time and may not represent the full range of exposures that may be experienced during dry and wet cutting of all types of block and brick under all conditions.

Respirable Dust Containing Silica

Table 1 summarizes the airborne dust concentrations and silica concentrations measured in the work areas and in the breathing zone of the workers. Table 1 also provides the value of the OSHA PEL that was calculated based on the measured silica content of the dust. The silica percentage in the area samples during dry cutting ranged from 5.7% to 14.3 % for the brick and 4.7% to 7.9% for the block. The mass of respirable dust collected in the general work area during wet sampling was too low to permit an evaluation of the silica content of the dust.

The silica percentage in the personal samples was 13.3% for the sample taken during dry cutting of brick, 4.2% and 12.7% for the two samples taken during dry cutting of block, and were below the limit of detection and 12.5% for the two samples taken during wet cutting of block.

Dry Cutting Brick and Block

The eleven area respirable dust concentrations for dry cutting brick and block ranged from 3.4 to 150 mg/m³, with a mean of 56 mg/m³. The five personal respirable dust samples concentrations ranged from 27 to 125 mg/m³, with a mean 53 mg/m³.

Wet Cutting Brick and Block

During wet cutting, fifteen of the seventeen area respirable dust concentrations were non-detectable, and two samples had a concentration of 0.3 mg/m³. The respirable dust concentrations measured on the two personal air samples were 0.3 mg/m³ and 0.7 mg/m³.

Real Time Dust Measurement and Video Monitoring

Figures 3 and 4 illustrate the temporal change in air concentration during wet and dry cutting. As expected, the concentration were high while cutting was underway and lower during the interval between cuts. Similar temporal variations were seen during both dry and wet operations. However, on average, the respirable dust concentration during wet cutting was 154 times lower than during dry cutting (Figure 5).

Figures 6 - 9 show the position of the worker, the average wind direction (if outdoors), and the dust concentrations at the worker location and the area sampling locations. Dust exposures were generally low when the worker was wet cutting, even while inside the building with minimal wind to disperse the dust (Figure 6). Outdoors, the concentration of dust at the worker's location was strongly influenced by the relative position of the worker and the saw relative to the direction of the wind, as would be expected. Locating the worker downwind of the saw (Figure 7) caused a four to five fold higher respirable dust exposure compared to locating the worker upwind of the saw (Figure 8). An intermediate concentration was observed when the wind was blowing from the side (Figure 9).

DISCUSSION

Most masonry materials contain crystalline silica. Crystalline silica can cause a disabling and often fatal lung disease known as silicosis. Chronic silicosis develops after prolonged exposure to relatively low concentrations of silica-containing dusts. Accelerated silicosis can occur after just five or ten years exposure to higher concentrations. Acute silicosis can develop after exposure to extreme concentrations for periods of years, or only weeks. Silicosis is irreversible. Cessation of exposure neither leads to remission, nor halts the disease process. Typically, the disease is neither clinically nor functionally apparent until years after the exposures. For these reasons, it is critically important that a control system or program be in place to prevent recurring high exposures. This system can consist of engineering controls (e.g., wet cutting, or cutoff saws equipped with local exhaust ventilation), work practices (e.g., positioning the cutoff process to take advantage of wind and natural dilution ventilation), and personal protective equipment. The order of preference is: engineering controls, work practices, and last, personal protective equipment.

It is clear from the results presented above that dry cutting should be avoided because of the risk it poses to both the operator and nearby workers. At dry-cutting dust levels, it takes only minutes to exceed the OSHA crystalline silica (quartz) Permissible Exposure Limit (PEL). In contrast, wet cutting results in a drastic reduction in exposures to dust. As a result, it may be possible to perform wet cutting for hours without exceeding the OSHA PEL.

Of the two personal samples taken during wet cutting, the amount of silica on one was less than the limit of detection, while on the other the amount detected was at the limit of detection (LOD) of 0.01mg. The calculated concentration for the latter was 0.1 mg/m³. The sample duration was 64 minutes. If cutting had continued at this rate for a full work shift, this concentration would have been above the NIOSH REL (recommended exposure limit) for silica dust (although it would have fallen below the OSHA PEL).⁴ If, however, cutting was limited to four hours out of the work shift, and if there were zero exposures throughout the remainder of the shift, the estimated full-shift, respirable silica (quartz) concentration would have been 0.05 mg/m³. This *predicted* concentration is equal to the NIOSH recommended exposure limit (0.05 mg/m³) for crystalline silica. Hence, based on these assumptions, wet cutting would protect workers from over-exposure if they cut for less than four hours. However, as noted above, additional data would be needed to draw definitive conclusions for the safety of wet cutting under all conditions.

The results in this HHE are consistent with the conclusions of other published reports. For example, information on the effectiveness of dust controls for cut-off saws was recently published in a United Kingdom professional journal.² The authors found that masonry cutting without controls can generate extremely high exposures of airborne dust. They also showed that reductions in exposure of upwards of 95% can be achieved with either wet cutting or cutting with local exhaust ventilation. Note, however, that a U.S. study of silica exposures in concrete workers and masons reported that "the use of water should not be relied upon as a complete method of control in all instances."³

The results in this HHE apply specifically to the brick and block used at that site. Different types or sources of brick or block may have greater

percentages of silica, resulting in greater exposures to crystalline silica when cutting for similar lengths of time. Routine measurements should be made to assure that workers are being protected.

CONCLUSIONS

Based on the results of this survey the following conclusions are made.

- Workers in close proximity to dry cutting operations are exposed to extremely high concentrations of airborne dust, of which a substantial proportion is silica dust.
- These levels are potentially hazardous to workers' health.
- When dry cutting, the cutting time for which exposure limits are exceeded may be as short as minutes as compared to hours for wet cutting.
- Wet cutting substantially reduces worker exposures to silica dust but does not entirely eliminate them.

RECOMMENDATIONS

The data collected by NIOSH suggest that, if the manufacturer's guidelines for using water while operating the saws are followed, Foeste masonry will likely be in compliance with OSHA standards and therefore no longer required to wear the half-mask respirator. However, there is an indication that long-term (full-shift) wet cutting may lead to the NIOSH REL being exceeded. Given this, and considering that this evaluation is limited in scope, NIOSH recommends that cutoff saw operators continue wearing at least a NIOSH-approved, disposable respirator, especially when cutting for two hours or more. The company should strive to reduce exposures below the NIOSH Recommended Exposure Limits (REL).⁵

NIOSH recommends the following:

- Avoid dry cutting.

- Use engineered controls such as wet cutting and/or saws with local dust capture attachments.
- Use administrative controls such as positioning the worker upwind of the saw or limiting the cutting time, as needed.
- Clean saws to prevent dust from being re-suspended from saw surfaces.
- Replace worn saw blades to prevent the generation of finer airborne dust.
- If dry cutting of brick or block is required, use appropriate respiratory protection, such as a Powered Air Purifying Respirator (PAPR) and limit the cutting time.
- Implement an ongoing dust measurement program to evaluate the effectiveness of the exposure control plan and demonstrate that the controls are sufficient to prevent over-exposure under all applicable conditions (i.e., types of brick and block, environmental conditions, and durations of cutting, etc).

REFERENCES

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Table 1: Summary of Airborne Dust and Silica Concentrations during Dry and Wet Cutting of Block and Brick

Area Sample ID	Cutting Process	Location/Sample Type	Sample Duration (min)	Quartz (mg)	Respirable Dust Conc. (mg/m3)	% Quartz	PEL (mg/m ³)
B00-1561	Dry	Outside/brick	14	0.048	18.6	12.6	0.7
B00-1563	Dry	Outside/brick	10	0.047	24.1	11.5	0.7
B00-1564	Dry	Outside/brick	14	0.01	3.4	14.3	0.6
B00-1568	Dry	Outside/brick	14	0.053	23.0	11.3	0.8
B00-1569	Dry	Outside/brick	10	0.24	150.6	9.4	0.9
B00-1593	Dry	Outside/brick	10	0.095	111.2	5.0	1.4
B00-1594	Dry	Outside/brick	10	0.098	100.6	5.7	1.3
B00-1575	Dry	Outside/block	10	0.03	22.4	7.9	1.0
B00-1576	Dry	Outside/block	10	0.075	69.4	6.4	1.2
B00-1565	Dry	Outside/block	10	0.02	25.3	4.7	1.5
B00-1577	Dry	Outside/block	10	0.063	65.3	5.7	1.3

Area Sample ID	Cutting Process	Location/Sample Type	Sample Duration (min)	Quartz (mg)	Respirable Dust Conc. (mg/m3)	% Quartz	PEL (mg/m ³)
B00-1579	Wet	Outside/block	64	*	*	*	*
B00-1580	Wet	Outside/block	64	*	*	*	*
B00-1589	Wet	Outside/block	64	*	*	*	*
B00-1590	Wet	Outside/block	64	*	*	*	*
B00-1591	Wet	Outside/block	64	*	*	*	*
B00-1592	Wet	Outside/block	64	*	*	*	*
B00-1597	Wet	Outside/block	64	*	*	*	*
B00-1598	Wet	Outside/block	64	*	*	*	*
B00-1599	Wet	Outside/block	64	*	*	*	*
B00-1601	Wet	Outside/block	64	*	*	*	*
B00-1581	Wet	Inside/block	76	ND	0.3	ND	5.0
B00-1585	Wet	Inside/block	76	*	*	*	*
B00-1586	Wet	Inside/block	76	*	*	*	*
B00-1587	Wet	Inside/block	76	*	*	*	*
B00-1588	Wet	Inside/block	48	*	*	*	*
B00-1595	Wet	Inside/block	76	*	*	*	*
B00-1570	Wet	Inside/block	76	ND	0.3	ND	5.0

Area Sample ID	Cutting Process	Location/Sample Type	Sample Duration (min)	Quartz (mg)	Respirable Dust Conc. (mg/m3)	% Quartz	PEL (mg/m ³)
B00-1574	Dry	Outside/brick	14	0.072	26.5	13.3	0.7
B00-1567	Dry	Outside/block	10	0.057	80.6	4.2	1.6
B00-1582	Dry	Outside/block	10	0.27	125.3	12.7	0.7
B00-1596	Wet	Outside/block	76	ND	0.3	ND	5.0
B00-1573	Wet	Outside/block	64	0.01	0.7	12.5	0.7

Field Blanks				
B00-1571-FB				ND
B00-1572-FB				ND
B00-1566-FB				ND

LOD - Limit of detection (0.01 mg)
 LOQ - Limit of quantitation (0.03 mg)
 * Sample not analyzed because total weight is below LOQ for silica.
 ND parameter not detected above LOD



Figure 1. Video snapshot during dry sawing of brick. A powered air purifying respirator is being worn by the worker. An air sampling station is located on a tripod to the left of the worker.



Figure 2. Video snapshot during wet sawing of block. A simple face shield is being worn by the worker for splash protection. Note the personal impactor air sampler on the left lapel of the worker.

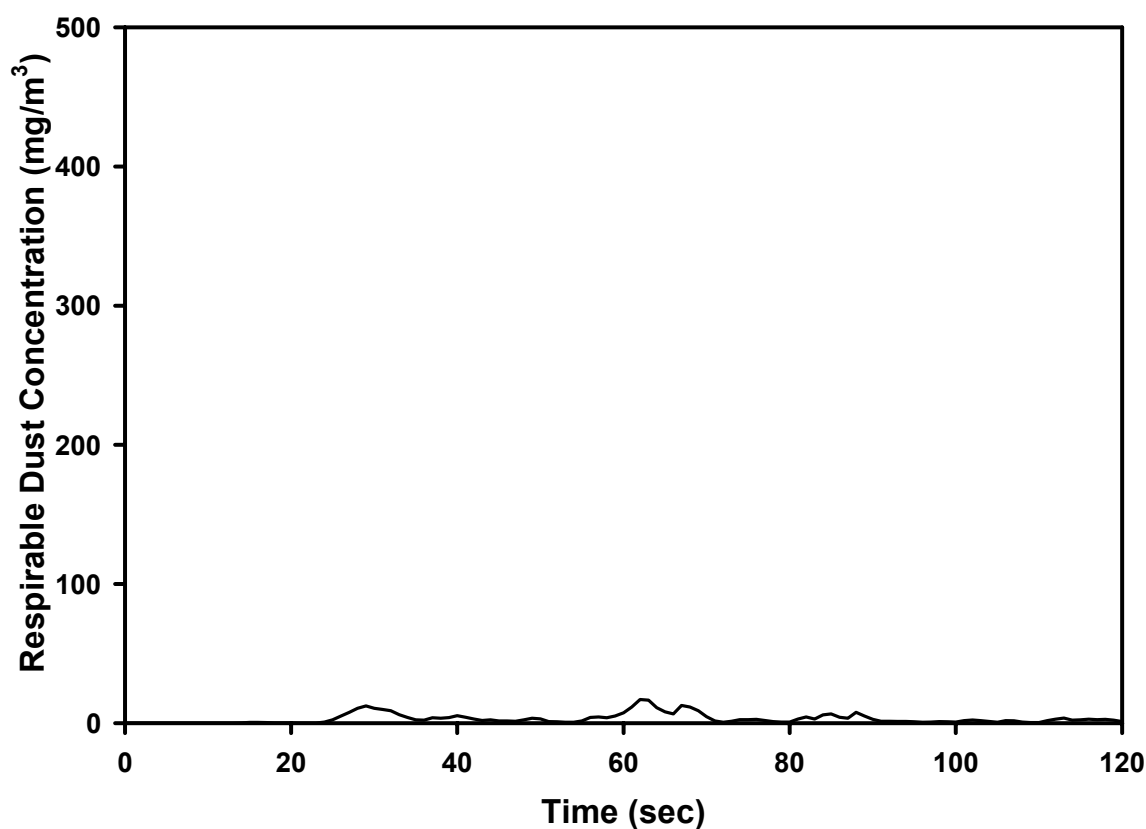


Figure 3. Typical dust concentration as a function of time during dry cutting of brick. Note the significant change in concentration during the course of the cutting operation.

Figure 4. Typical dust concentration as a function of time during wet cutting of block. Small changes in concentration are seen during the wet cutting process but the overall dust concentration is very low.

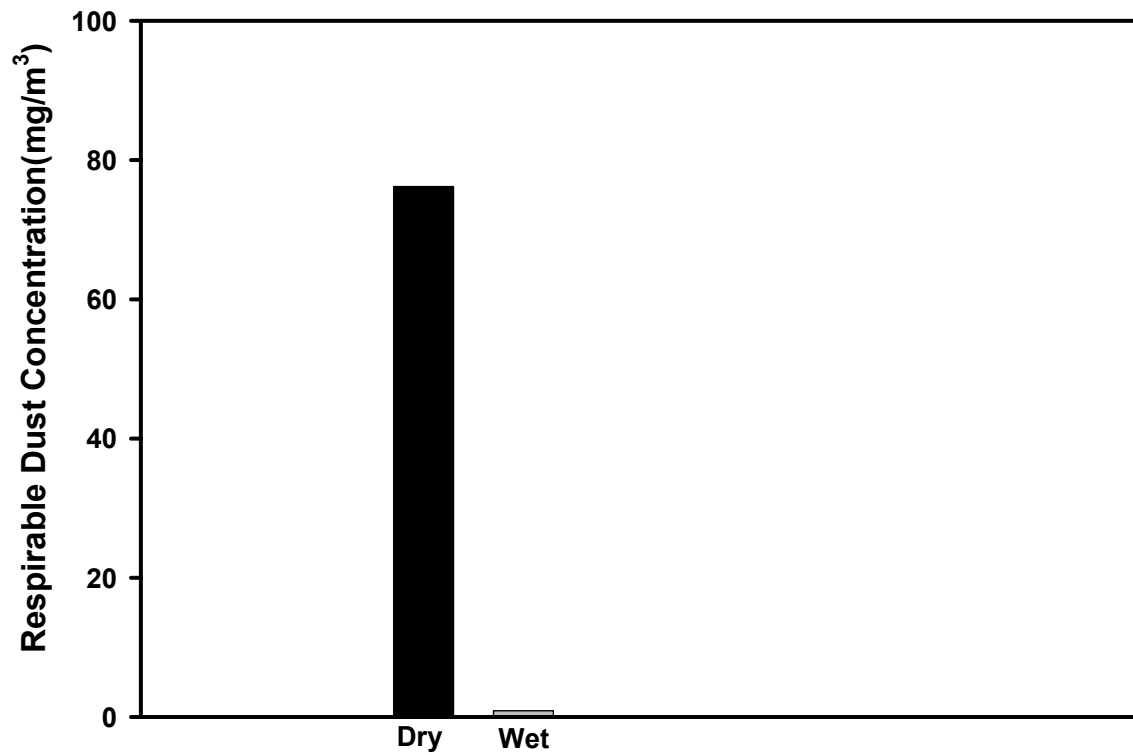


Figure 5. Comparison of the average personal dust concentration during dry and wet cutting of block. The average concentration during wet cutting is 154 times lower than during dry cutting.

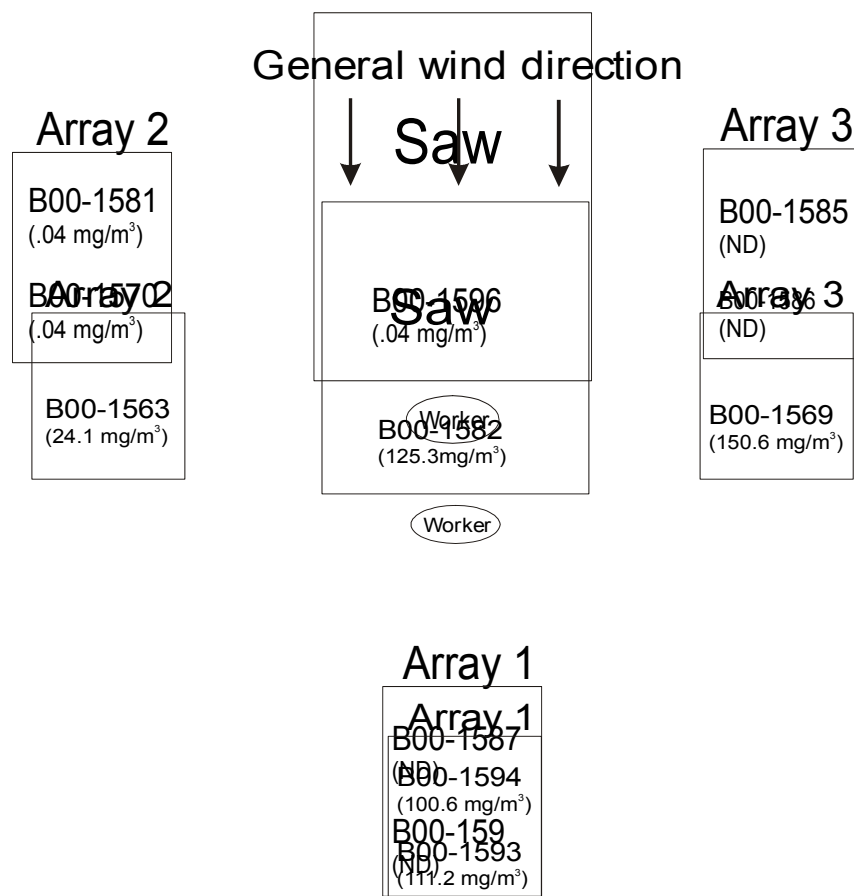


Figure 6. Position of saw, worker, and air sampling array for wet sawing of block inside a building at the worksite. Sample numbers and associated dust concentrations are noted at each sampling location. ND is non-detected.

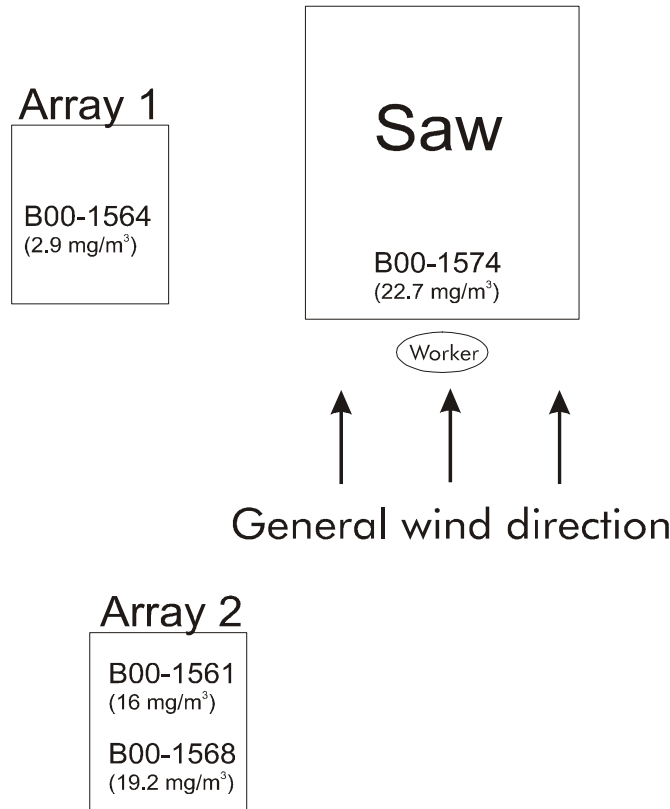


Figure 7. Illustration of a typical outside setup for measuring the concentration of airborne dust during dry cutting of

brick at the worksite. Note that the wind is bring the dust directly toward the worker.

Figure 8. Illustration of an alternate outside setup for measuring the concentration of airborne dust during dry cutting of brick at the worksite. Note that the wind is carrying the dust away from the worker, resulting in a significantly lower concentration of airborne dust at the worker's location.

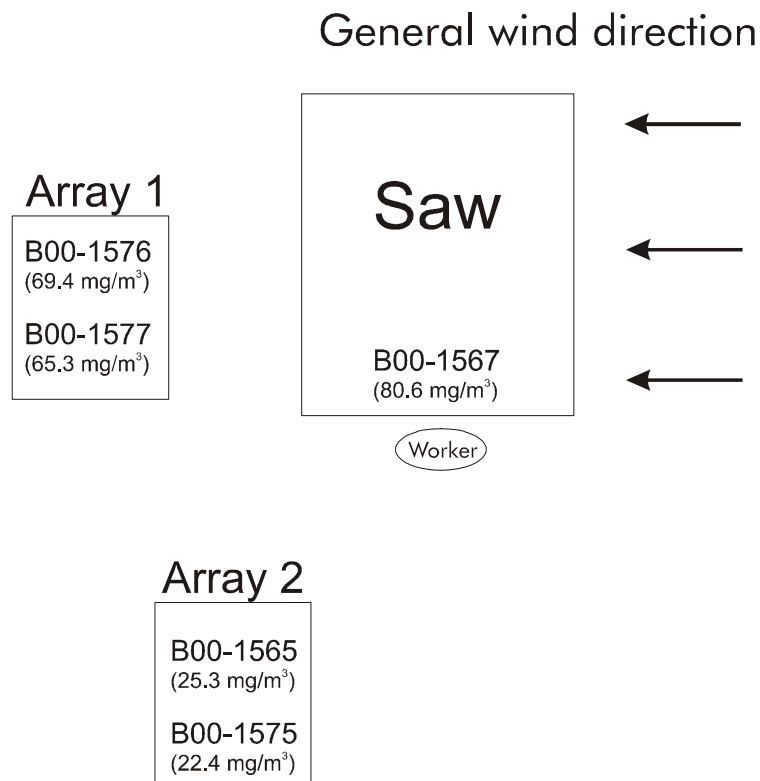


Figure 9. Illustration of a typical outside setup for measuring the dust concentration of airborne dust during dry cutting of brick at the worksite. Note the change in wind direction from the previous two figures. The wind direction is from the side, resulting in an intermediate concentration of airborne dust at the worker's location.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. Note, however, that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),^(A1) (2) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs),^(A2) and (3) the American Conference of Governmental Industrial Hygienists' (ACGIH[®]) Threshold Limit Values (TLVs[®]).^(A3) Employers are encouraged to follow the NIOSH RELs, the OSHA PEL's, the ACGIH TLVs, or whichever are the more protective criterion. OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 95-596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

NIOSH and ACGIH recommend that exposure to respirable crystalline silica (as quartz or cristobalite) be controlled so that no worker is exposed to a TWA concentration greater than 0.05 mg/m³. The OSHA permissible exposure limit (PEL) for respirable dust containing crystalline silica is based on the type of silica (e.g., quartz or cristobalite) and the percentage of silica found in respirable airborne samples. With this information the PEL is calculated for each sample using the following formula:

$$\text{PEL}_{\text{respirable dust containing quartz}} = \frac{10 \text{ mg/m}^3}{\% \text{ Quartz} + 2}$$

For respirable dust containing cristobalite, the PEL is ½ the value calculated from the quartz formula.

APPENDIX REFERENCES

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- A3. ACGIH [2000]. 2000 TLVs[®] and BEIs[®]: Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

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